

[54] ACIDPROOF, HYDROLYSIS-RESISTANT
OPTICAL AND OPHTHALMIC GLASS OF
LOW DENSITY[75] Inventors: Karl Mennemann, Taunusstein;
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501/903, 75, 76

[56] References Cited

U.S. PATENT DOCUMENTS

3,877,953 4/1975 Broemer et al. 501/903
3,898,093 8/1975 Faulstich et al. 106/54
4,055,435 10/1977 Sagara 106/52
4,057,435 11/1977 Boudot et al. 106/47
4,084,978 4/1978 Sagara 501/903
4,194,916 3/1980 Kumata et al. 106/47

FOREIGN PATENT DOCUMENTS

2809409 9/1978 Fed. Rep. of Germany .
1591210 6/1981 United Kingdom .

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[57]

ABSTRACT

An optical and ophthalmic glass having an index of refraction of ≥ 1.69 , an Abbe number of ≥ 37 , and a density of ≤ 3.30 g/cm³, consists essentially of (in % by weight):

SiO ₂	18-36
B ₂ O ₃	3-18
GeO ₂	0-8
Al ₂ O ₃	0-6,
wherein SiO ₂ + B ₂ O ₃ + Al ₂ O ₃ + GeO ₂ =	25-39
P ₂ O ₅	0-14,
wherein SiO ₂ + B ₂ O ₃ + Al ₂ O ₃ + GeO ₂ + P ₂ O ₅ =	30-44
Li ₂ O	0-12
Na ₂ O	0-14
K ₂ O	0-18
Li ₂ O + Na ₂ O + K ₂ O =	2-18
MgO	0-19
CaO	2-25
MgO + CaO	15-32
SrO	0-15
BaO	0-17
ZnO	0-15
PbO	0-10
SrO + BaO + ZnO + PbO	0-20
TiO ₂	3-14
Nb ₂ O ₅	0-13
WO ₃	0-10
TiO ₂ + Nb ₂ O ₅ + WO ₃ =	10-21
ZrO ₂	0-15,
La ₂ O ₃	0-20
Y ₂ O ₃	0-16
Gd ₂ O ₃	0-16
Yb ₂ O ₃	0-10
La ₂ O ₃ + Y ₂ O ₃ + Gd ₂ O ₃ + Yb ₂ O ₃ =	0-20
Ta ₂ O ₅	0-13
HfO ₂	0-5
SnO ₂	0-6.

14 Claims, No Drawings

ACIDPROOF, HYDROLYSIS-RESISTANT OPTICAL AND OPHTHALMIC GLASS OF LOW DENSITY

BACKGROUND OF THE INVENTION

The present invention relates to a lightweight, acid-proof, hydrolysis-resistant optical and ophthalmic glass having an index of refraction $n_d \approx 1.69$, an Abbe number $v_d \approx 37$, and a density $s \approx 3.30$ g/cm³. It is a borosilicate glass in the system SiO₂-B₂O₃-CaO-TiO₂.

Lightweight glasses of a high refractive index, for example for ophthalmic optics or for optical systems have been described in DAS [German Published Application] No. 2,259,183. These glasses, having a density of about 3.0 g/cm³, are especially well suited for strong corrections, but exhibit the grave disadvantage of strong dispersion, i.e., they have a comparatively low Abbe number ≤ 33 . This strong dispersion causes a person wearing glasses of this type to see pronounced color fringes. For this reason, attempts have been made to improve their dispersion while retaining the same or only a slightly increased specific density (French Pat. No. 2,427,309). These new glasses, however, also fail to meet the requirements for a v_d value ≥ 37 which generally would be highly desirable.

In further developments, glasses were provided having an increased Abbe number; however, they cannot be manufactured continuously due to their instability toward crystallization. In addition, their chemical resistance (acidproofness and resistance to climatic changes) do not satisfy the requirements imposed on spectacle lenses. Glasses of this type are described in DOS [German Unexamined Laid-Open Application] No. 2,809,409 and DAS No. 2,715,894, as well as DAS No. 2,623,683.

Accordingly, it is an object of the present invention to provide a new optical and ophthalmic glass which meets the aforementioned requirements and avoids the aforementioned disadvantages.

Upon further study of the specification and appended claims, further objects and advantages of this invention will become apparent to those skilled in the art.

These objects have been attained by providing an optical and ophthalmic glass having an index of refraction of ≥ 1.69 , (e.g., 1.69-1.71), an Abbe number of ≥ 37 , (e.g., 37-43) and a density of ≤ 3.30 g/cm³, (e.g., 3.30-3.10), comprising (in % by weight):

	General Range	Preferred Range, When Included
SiO ₂	18-36	18-36
B ₂ O ₃	3-18	3-18
GeO ₂	0-8	0-8
Al ₂ O ₃	0-6	0-6
wherein SiO ₂ + B ₂ O ₃ + Al ₂ O ₃ + GeO ₂ = 25-39		
P ₂ O ₅	0-14	0.5-4
wherein SiO ₂ + B ₂ O ₃ + Al ₂ O ₃ + GeO ₂ + P ₂ O ₅ = 30-44		
Li ₂ O	0-12	0-12
Na ₂ O	0-14	0-14
K ₂ O	0-18	0-18
Li ₂ O + Na ₂ O + K ₂ O = 2-18		
MgO	0-15	0-15
CaO	7-25	7-25
MgO + CaO	15-32	15-32
SrO	0-13	0-13
BaO	0-17	0-17
ZnO	0-15	0-15
PbO	0-10	0-10
SrO + BaO + ZnO + PbO = 0-20		

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	General Range	Preferred Range, When Included
TiO ₂	3-14	3-14
Nb ₂ O ₅	0-13	0-13
WO ₃	0-10	0-10
TiO ₂ + Nb ₂ O ₅ + WO ₃ = 10-21		
ZrO ₂	0-15	3-8
La ₂ O ₃	0-20	3-12
Y ₂ O ₃	0-16	0-16
Gd ₂ O ₃	0-16	0-16
Yb ₂ O ₃	0-10	0-10
La ₂ O ₃ + Y ₂ O ₃ + Gd ₂ O ₃ + Yb ₂ O ₃ = 0-20		
Ta ₂ O ₅	0-13	3-12
HfO ₂	0-5	0-13
SnO ₂	0-6	0-5
		0-6

A particularly preferred such glass has a v_d value of ≥ 39 and a density s of ≤ 3.2 g/cm³, is sufficiently stable with respect to crystallization to permit continuous manufacture and simultaneously satisfies the minimum requirements for acid resistance and resistance against climatic changes, and comprises (% by weight):

B ₂ O ₃	5-14
SiO ₂	24-32
Al ₂ O ₃	0-6
GeO ₂	0-8
B ₂ O ₃ + SiO ₂ + Al ₂ O ₃ + GeO ₂ = 33-39	
P ₂ O ₅	0-6
B ₂ O ₃ + SiO ₂ + Al ₂ O ₃ + GeO ₂ + P ₂ O ₅ = 37-43	
Li ₂ O	0-7
Na ₂ O	0-8
K ₂ O	0-11
Li ₂ O + Na ₂ O + K ₂ O = 4-14	
MgO	0-10
CaO	12-25
MgO + CaO = 18-27	
ZnO	0-8
BaO	0-6
SrO	0-6
PbO	0-5
ZnO + BaO + SrO + PbO = 0-8	
TiO ₂	6-10
Nb ₂ O ₅	0-8
WO ₃	0-10
TiO ₂ + Nb ₂ O ₅ + WO ₃ = 13-19	
ZrO ₂	3-9
La ₂ O ₃	0-11
Y ₂ O ₃	0-12
Gd ₂ O ₃	0-8
Yb ₂ O ₃	0-7
La ₂ O ₃ + Y ₂ O ₃ + Gd ₂ O ₃ + Yb ₂ O ₃ = 0-14	
Ta ₂ O ₅	0-7
HfO ₂	0-6
SnO ₂	0-6

DETAILED DISCUSSION

The present invention makes it possible to continuously produce spectacle glass and optical glasses with adequate chemical resistance (e.g., acidproofness and water resistance), with an index of refraction of about 1.7 and an Abbe number ≥ 37 , at a density of ≤ 3.30 g/cm³; at the same time, fusion with commercial spectacle crown glass can be ensured by setting its expansion coefficient $\alpha(20-300) \cdot 10^{-7}$ at 90-98, e.g., by conventional selection of suitable amounts of the following ingredients: Na₂O, K₂O, Li₂O.

According to this invention, a borosilicate glass is chosen as the basic glass system. As is known, this particular one has an excellently high chemical resistance. This basic glass system is combined with components

increasing the refractive index, primarily, the light alkaline earth metal oxides MgO and CaO, especially CaO, and with components greatly raising the index of refraction while not impairing the Abbe number too extensively, i.e., Nb₂O₅ and TiO₂ as well as ZrO₂. In order to stabilize this system against reparation, an addition of alkali metal oxide is necessary.

It has been found that this system, which is only moderately stable with respect to devitrification and which also exhibits insufficient chemical resistance due to its high content of alkaline earth metal oxides as well as alkali metal oxides, can be improved with regard to both aforementioned properties—devitrification stability and chemical resistance—if P₂O₅ is added thereto.

The glass according to this invention is made up of the following components in the recited ranges (in % by weight):

SiO ₂	18-36
B ₂ O ₃	3-18
GeO ₂	0-8
Al ₂ O ₃	0-6

wherein the sum total of these tri- and tetravalent vitrifying agents amounts to 25-39% by weight.

As indicated above, the devitrification stability can be improved, along with the chemical resistance, by adding the pentavalent vitrifying agent P₂O₅; for this reason, an addition of a few percent of P₂O₅ is useful. An addition of > 14%, however, renders the glass unstable against devitrification. Preferred is 0.5-4.0% of P₂O₅. The sum total of the tri- and tetravalent vitrifying agents plus P₂O₅ amounts to 30-44% by weight.

As mentioned, the addition of an alkali metal is required to prevent demixing. This can be achieved by the following additions:

	% by Weight
Li ₂ O	0-12
Na ₂ O	0-14
K ₂ O	0-18
Li ₂ O + Na ₂ O + K ₂ O =	2-18

If the proportion of alkali metal oxides > 18%, devitrification stability and chemical resistance are negatively affected.

CaO is added as an essential component. It achieves a marked rise in the index of refraction, while ensuring a high Abbe number and simultaneously maintaining a low density. The function of the CaO can also be co-achieved per the following by MgO within relatively wide limits. The proportions of the light alkaline earth metal oxides MgO and CaO are:

	% by Weight
MgO	0-15
CaO	7-25
MgO + CaO =	15-32

From the heavy alkaline earth metal oxides SrO and BaO, the following proportions can be added, if necessary, e.g., in order to adjust the density:

SrO	0-13% by weight
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BaO	0-17% by weight;
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furthermore permissible are:

ZnO	0-15% by weight
PbO	0-10% by weight,

with the condition: $SrO + BaO + ZnO + PbO \leq 20\%$, since the density increases greatly at larger proportions.

Another absolutely necessary component of the glass of this invention is TiO₂ since, as is known, the index of refraction is thereby greatly raised while the density increases by only a small amount. An addition of 3-14% by weight is required to raise the index of refraction to the desired value of > 1.69. Another positive property added by TiO₂ is an improvement in chemical resistance.

Similar effects as for TiO₂ are exhibited by Nb₂O₅ and WO₃. These oxides can be added in amounts of

Nb ₂ O ₅	0-13% by weight
WO ₃	0-10% by weight

The sum total of these three oxides TiO₂, Nb₂O₅, WO₃, similar in properties, is 10-21% by weight.

Another usable oxide is ZrO₂. This compound greatly increases the index of refraction, but reduces the Abbe number only moderately, while improving the chemical resistance to a marked extent. This oxide can be added in proportions of 0-15% by weight; a proportion of 3-9% by weight is preferred.

To stabilize the glass further against devitrification, the following can be added per this invention:

La ₂ O ₃	0-20% by weight
Y ₂ O ₃	0-16% by weight
Gd ₂ O ₃	0-16% by weight
Yb ₂ O ₃	0-10% by weight
Total	0-20% by weight

Furthermore, an addition of 0-13% Ta₂O₅ is possible. HfO₂ can be added in amounts of 0-5% by weight, and also SnO₂ in 0-6% by weight. These ions are added for purposes of adjusting the index of refraction.

A portion of the oxygen ions (e.g., 0-1% by weight) can be replaced by fluoride ions by introducing a fluoride into the glass melt instead of an oxide. Fluoride ions may be added for the purpose of decreasing the melting temperature and stabilizing the glass against devitrification.

EXAMPLE OF A MELT

Glass batch charged for 220 Kg of glass

	% by Weight	Raw Material	Weighted Quantity in kg
B ₂ O ₃	11.25	H ₃ BO ₃	43.88
SiO ₂	24.00	SiO ₂	52.88
P ₂ O ₅	3.10	P ₂ O ₅	6.82
Li ₂ O	0.70	Li ₂ CO ₃	3.85
Na ₂ O	4.50	Na ₂ CO ₃	17.00
K ₂ O	4.55	K ₂ CO ₃	14.70
MgO	2.90	MgCO ₃	15.08
CaO	16.30	CaCO ₃	63.26
La ₂ O ₃	6.60	La ₂ O ₃	14.55
TiO ₂	9.00	TiO ₂	19.82
ZrO ₂	1.65	ZrO ₂	3.65

-continued

EXAMPLE OF A MELT			
Glass batch charged for 220 Kg of glass			
	% by Weight	Raw Material	Weighed Quantity in kg
Nb ₂ O ₅	2.60	Nb ₂ O ₅	5.72
Ta ₂ O ₅	12.85	Ta ₂ O ₅	28.30

The individual oxides can also be introduced in complex form, for example P₂O₅ bound to the alkali or alkaline earth oxides, e.g., as CaPO₃ or Ca₂P₂O₇. It is also possible, for example, to use SiO₂ in part as CaSiO₃ or, for example, as ZrSiO₄ with appropriate stoichiometric conversion. It is likewise feasible to introduce small amounts of a fluoride, e.g., as an alkali metal, alkaline earth metal, or rare earth fluoride. As₂O₃ or Sb₂O₃ is added to the batch as the refining agent (e.g., in amounts of 0.1-1% by weight); then the batch is mixed thoroughly and melted at approximately 1400° C. in a

Pt crucible or a ceramic trough within about 8 hours. After a refining time of about 3 hours, the batch is stirred until the discharge or pouring temperature has been reached. The glass is conventionally either poured into casting molds or press-molded. The glass of this invention is particularly useful as spectacle glass requiring strong correction.

Without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilize the present invention to its fullest extent. The following preferred specific embodiments are, therefore, to be construed as merely illustrative, and not limitative of the remainder of the disclosure in any way whatsoever. In the following examples, all temperatures are set forth uncorrected in degrees Celsius; unless otherwise indicated, all parts and percentages are by weight.

TABLE

(Examples in % by Weight)							
	1	2	3	4	5	6	7
B ₂ O ₃	3.20	17.75	9.10	9.50	12.95	10.25	9.80
SiO ₂	34.80	18.60	21.60	24.00	23.55	22.80	21.60
Al ₂ O ₃	—	—	—	—	—	5.10	—
GeO ₂	—	—	—	—	—	—	—
P ₂ O ₅	—	1.80	—	1.30	4.75	—	7.10
Li ₂ O	2.07	1.15	—	—	9.15	1.45	1.10
Na ₂ O	0.70	3.15	—	12.10	—	3.00	2.30
K ₂ O	6.50	4.80	17.15	—	—	4.60	4.65
MgO	3.75	6.20	5.45	5.85	5.00	5.95	6.50
CaO	11.90	15.70	17.00	16.30	14.90	16.50	16.00
SrO	—	—	—	—	—	—	—
BaO	—	—	—	—	2.15	—	—
ZnO	—	2.05	1.85	2.00	2.25	2.00	2.00
PbO	—	—	—	—	—	—	—
La ₂ O ₃	19.88	7.50	7.30	7.90	—	8.00	8.10
Y ₂ O ₃	—	—	—	—	—	—	—
Gd ₂ O ₃	—	—	—	—	—	—	—
Y ₂ O ₃	—	—	—	—	—	—	—
TiO ₂	7.80	8.15	9.00	8.70	8.90	7.80	7.95
ZrO ₂	5.70	6.30	5.55	6.00	6.90	6.00	6.15
Nb ₂ O ₅	3.70	6.85	6.00	6.35	7.50	6.55	6.75
WO ₃	—	—	—	—	—	—	—
Ta ₂ O ₅	—	—	—	—	—	—	—
nd	1.6990	1.6982	1.6920	1.6943	1.7026	1.6977	1.6949
vd	40.5	39.5	38.6	38.5	39.9	39.2	39.3
S	3.30	3.14	3.12	3.16	3.02	3.15	3.17
	8	9	10	11	12	13	14
B ₂ O ₃	7.85	11.45	12.50	11.20	11.60	11.35	11.35
SiO ₂	29.50	25.80	25.80	25.00	26.00	26.15	25.40
Al ₂ O ₃	—	—	—	—	—	—	—
GeO ₂	—	—	—	—	—	—	—
P ₂ O ₅	1.45	—	—	—	—	—	—
Li ₂ O	1.40	1.50	1.50	1.40	2.90	—	1.40
Na ₂ O	2.90	3.10	3.10	2.90	3.00	5.90	3.00
K ₂ O	4.40	4.75	4.70	4.40	—	4.50	4.50
MgO	—	14.25	0.50	5.70	5.90	3.85	5.80
CaO	19.80	7.05	24.75	7.90	11.00	8.70	14.70
SrO	—	—	—	12.10	—	—	—
BaO	3.60	—	—	—	16.80	—	—
ZnO	—	2.05	0.60	1.90	—	14.60	1.95
PbO	—	—	—	—	—	—	9.60
La ₂ O ₃	13.70	8.20	6.55	7.65	—	5.20	—
Y ₂ O ₃	—	—	—	—	—	—	3.60
Gd ₂ O ₃	—	—	—	—	—	—	—
Yb ₂ O ₃	—	—	—	—	—	—	—
TiO ₂	6.35	8.05	7.95	7.50	10.20	7.60	7.15
ZrO	2.90	7.00	6.10	5.80	6.00	5.90	5.80
Nb ₂ O ₅	6.15	6.80	5.95	6.55	6.60	6.25	5.75
WO ₃	—	—	—	—	—	—	—
Ta ₂ O ₅	—	—	—	—	—	—	—
nd	1.6991	1.7051	1.7005	1.7000	1.7075	1.6982	1.7064
vd	41.6	38.1	40.5	40.0	38.3	38.5	37.10
S	3.29	3.17	3.12	3.30	3.29	3.26	3.25
	15	16	17	18	19	20	21
B ₂ O ₃	7.75	8.10	11.20	11.60	11.25	9.80	11.15

TABLE-continued

(Examples in % by Weight)

	28.60	28.25	25.50	26.00	24.00	26.45	25.45
SiO ₂	—	—	—	—	—	—	—
Al ₂ O ₃	—	—	—	—	—	—	—
GeO ₂	—	—	—	—	—	—	—
P ₂ O ₅	—	3.40	—	—	3.10	2.45	2.50
Li ₂ O	—	1.45	1.45	1.45	0.70	0.75	1.50
Na ₂ O	4.45	3.00	3.00	3.00	4.50	3.10	3.15
K ₂ O	6.70	4.50	4.50	4.50	4.55	7.00	4.75
MgO	3.85	3.90	5.95	4.40	2.90	6.00	7.15
CaO	15.20	14.90	16.65	15.05	16.30	15.30	14.20
SrO	—	—	—	—	—	—	—
BaO	—	—	—	—	—	—	—
ZnO	—	—	1.00	—	—	2.00	—
PbO	—	—	—	—	—	—	—
La ₂ O ₃	—	16.25	—	7.95	6.60	8.10	—
Y ₂ O ₃	14.85	—	3.70	—	—	—	—
Gd ₂ O ₃	—	—	3.00	—	—	—	—
Yb ₂ O ₃	—	—	—	—	—	—	9.20
TiO ₂	7.90	8.70	3.95	9.75	10.55	12.90	11.10
ZrO ₂	4.40	3.70	7.60	6.00	—	6.15	3.10
Nb ₂ O ₅	6.30	3.85	12.50	0.60	2.60	—	6.75
WO ₃	—	—	—	9.70	—	—	—
Ta ₂ O ₅	—	—	—	—	12.85	—	—
nd	1.7044	1.7056	1.7013	1.6981	1.7005	11.6990	1.6978
vd	40.0	41.2	40.5	39.0	37.9	38.10	37.8
S	3.18	3.27	3.19	3.22	3.26	3.12	3.16

	22	23	24	25
B ₂ O ₃	6.90	12.65	11.25	11.40
SiO ₂	18.60	26.30	21.10	23.65
Al ₂ O ₃	—	—	—	—
GeO ₂	—	—	6.35	—
P ₂ O ₅	12.06	1.10	1.40	—
Li ₂ O	2.22	2.30	1.45	1.45
Na ₂ O	3.07	—	3.00	3.00
K ₂ O	2.33	—	4.55	4.60
MgO	6.99	6.15	5.90	6.95
CaO	15.98	21.35	15.00	24.50
SrO	—	—	—	—
BaO	—	—	—	—
ZnO	2.02	5.10	1.95	—
PbO	—	—	—	—
La ₂ O ₃	8.07	8.30	7.90	6.10
Y ₂ O ₃	—	—	—	—
Gd ₂ O ₃	—	—	—	—
Ab ₂ O ₃	—	—	—	—
TiO ₂	7.92	5.10	7.75	6.30
ZrO ₂	6.56	6.25	6.00	6.05
Nb ₂ O ₅	6.45	5.40	6.40	6.00
WO ₃	—	—	—	—
Ta ₂ O ₅	—	—	—	—
SnO	0.50	—	—	—
nd	1.7049	1.7052	1.7048	1.6995
vd	39.2	42.1	39.1	41.0
S	3.17	3.13	3.27	3.15

The preceding examples can be repeated with similar success by substituting the generically or specifically 50 described reactants and/or operating conditions of this invention for those used in the preceding examples. From the foregoing description, one skilled in the art can easily ascertain the essential characteristics of this invention, and without departing from the spirit and 55 scope thereof, can make various changes and modifications of the invention to adapt it to various usages and conditions.

What is claimed is:

1. An optical ophthalmic glass having an index of 60 refraction of ≥ 1.69 , an Abbe number of ≥ 37 , and a density of ≤ 3.30 g/cm³, consisting essentially of (in % by weight):

SiO ₂	18-36
B ₂ O ₃	3-18
GeO ₂	0-8
Al ₂ O ₃	0-6

-continued

wherein SiO ₂ + B ₂ O ₃ + Al ₂ O ₃ + GeO ₂ =	25-39
P ₂ O ₅	0-14
wherein SiO ₂ + B ₂ O ₃ + Al ₂ O ₃ + GeO ₂ + P ₂ O ₅ =	30-44
Li ₂ O	0-12
Na ₂ O	0-14
K ₂ O	0-18
Li ₂ O + Na ₂ O + K ₂ O =	2-18
MgO	0-15
CaO	7-21.35
MgO + CaO	15-32
SrO	0-13
BaO	0-17
ZnO	0-15
PbO	0-10
SrO + BaO + ZnO + PbO	0-20
TiO ₂	3.95-14
Nb ₂ O ₅	0-13
WO ₃	0-10
TiO ₂ + Nb ₂ O ₅ + WO ₃ =	10-21
ZrO ₂	2.9-15
La ₂ O ₃	0-20
Y ₂ O ₃	0-16
Gd ₂ O ₃	0-16

-continued

Yb ₂ O ₃	0-10
La ₂ O ₃ + Y ₂ O ₃ + Gd ₂ O ₃ + Yb ₂ O ₃ =	0-20
Ta ₂ O ₅	0-13
HfO ₂	0-6
SnO ₂	0-6

2. An optical and ophthalmic glass of claim 1 having an Abbe number of ≥ 39 and a density of ≤ 3.2 g/cm³, which is sufficiently stable with respect to crystallization to permit continuous manufacture, and which is acid resistant and resistant to climatic changes, consisting essentially of (% by weight):

B ₂ O ₃	5-14
SiO ₂	24-32
Al ₂ O ₃	0-6
GeO ₂	0-8
B ₂ O ₃ + SiO ₂ + Al ₂ O ₃ + GeO ₂ =	33-39
P ₂ O ₅	0-6
B ₂ O ₃ + SiO ₂ + Al ₂ O ₃ + GeO ₂ + P ₂ O ₅ =	37-43
Li ₂ O	0-7
Na ₂ O	0-8
K ₂ O	0-11
Li ₂ O + Na ₂ O + K ₂ O =	4-14
MgO	0-10
CaO	12-21.35
MgO + CaO =	18-27
ZnO	0-8
BaO	0-6
SrO	0-5
PbO	0-5
ZnO + BaO + SrO + PbO =	0-8
TiO ₂	6-10
Nb ₂ O ₅	0-8

-continued

WO ₃	0-10
TiO ₂ + Nb ₂ O ₅ + WO ₃ =	13-19
ZrO ₂	3-9
La ₂ O ₃	0-11
Y ₂ O ₃	0-12
Gd ₂ O ₃	0-8
Yb ₂ O ₃	0-7
La ₂ O ₃ + Y ₂ O ₃ + Gd ₂ O ₃ + Yb ₂ O ₃ =	0-14
Ta ₂ O ₅	0-7
HfO ₂	0-6
SnO ₂	0-6

3. A glass of claim 1 wherein the amount of TiO₂ is 6-10%.

15 4. A glass of claim 1 wherein 0-1% of the oxygen ions are replaced by fluoride ions.

5. A lens made of glass of claim 1 or 2.

6. A lens of claim 5 for eyeglasses.

20 7. A glass of claim 1 wherein the amount of TiO₂ is 6-14%.

8. A glass of claim 1 wherein the amount of TiO₂ is 3.95-10%.

9. A glass of claim 1 wherein the amount of ZrO₂ is 3-8%.

25 10. A glass of claim 3 wherein the amount of ZrO₂ is 3-8%.

11. A glass of claim 7 wherein the amount of ZrO₂ is 3-8%.

30 12. A glass of claim 1 wherein the amount of ZrO₂ is 3-15%.

13. A glass of claim 3 wherein the amount of ZrO₂ is 3-15%.

14. A glass of claim 7 wherein the amount of ZrO₂ is 3-15%.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 4,390,638

DATED : June 28, 1983

INVENTOR(S) : KARL MENNEMANN ET AL

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 10, lines 9 and 10: Reads " Ta_2O 0-7
" HfO_2 0-6"

Should read -- Ta_2O_5 0-7
 HfO_2 0-5 --

Signed and Sealed this

Thirteenth Day of September 1983

[SEAL]

Attest:

GERALD J. MOSSINGHOFF

Attesting Officer

Commissioner of Patents and Trademarks